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NEW YORK UNIV N Y COURANT INST OF MATHEMATICAL SCIENCES F/G 20/11
WAVE PROPAGATION, THE DYNAMICS OF ELASTIC STRUCTURES AND STABIL--ETC(U)
1977 E L REISS AF-AFOSR-2107-71

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New York University
Courant Institute of Mathematical Sciences

Final Report
Grant No. AFOSR71-2107

Wave Propagation, the Dynamics of Elastic Structures
and Stability, and Neutron Transport

Prepared for

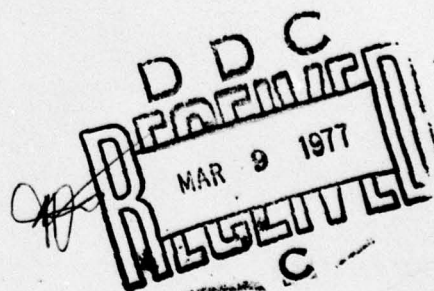
Air Force Office of Scientific Research
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Edward L. Reiss

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Project Director

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFOSR - TR - 77 - 0068	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) WAVE PROPAGATION, THE DYNAMICS OF ELASTIC STRUCTURES AND STABILITY, AND NEUTRON TRANSPORT		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Edward L. Reiss		8. CONTRACT OR GRANT NUMBER(s) AFOSR 71-2107
9. PERFORMING ORGANIZATION NAME AND ADDRESS New York University Courant Institute of Mathematical Sciences New York, New York 10012		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61102F 2304/A4
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Office of Scientific Research/NM Bolling AFB, Washington, DC 20332		12. REPORT DATE 1977
		13. NUMBER OF PAGES 7
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A total of nine investigators completed 32 research projects yielding 22 publications, 10 accepted or submitted, and 5 in preparation. Subject areas were structural analysis (12), wave propagation (13), fluid dynamics (5), and transport theory (5). Topics included higher order buckling in the presence of imperfections, dynamic instability, composite material, wave propagation through nonlinear and random media, vortex motion in fluids, the small mean free path approximation to the transport equations, etc. Asymptotic, perturbation and bifurcation techniques predominated. The application of the techniques of		

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20 Abstract

stretching and matching from asymptotic theory to bifurcation problems might be considered a breakthrough, funded by AFOSR, ONR and ARO, with applications in buckling, flutter, flame stability, etc.

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A total of nine investigators completed 13 research projects. The results of these investigations are presented in this report. The first three projects were carried out by the Courant Institute of Mathematical Sciences, New York, New York. The remaining six projects were carried out by the Air Force Office of Scientific Research, Rolling Hill, Washington, DC. The results of these investigations are presented in this report. The first three projects were carried out by the Courant Institute of Mathematical Sciences, New York, New York. The remaining six projects were carried out by the Air Force Office of Scientific Research, Rolling Hill, Washington, DC. The results of these investigations are presented in this report.

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During the past 5 years in which we worked on this contract, 32 research projects were completed. This resulted in 22 publications, and 10 papers which have either been accepted for publication or submitted for publication. In addition, there are several other papers in preparation. All of these publications are listed in Appendix A of this report.

Aircraft and missile structures are subjected to a variety of static and dynamic loads when in flight. As a result, the structure or components of it, may buckle or respond nonlinearly in other ways. The responses of the structure, and their interactions with the air, are described by boundary and initial value problems for ordinary and partial differential equations. We have analyzed a variety of these problems by using asymptotic and perturbation methods, and methods of bifurcation theory. We have developed new methods and applied them to solve specific problems. These are described in reports AFH 5, 17, 23-26, 33, 34, 36, and 37. The main results consist of: new methods for analyzing buckling (bifurcation) in the presence of imperfections; a new perturbation method for analyzing secondary transitions; and a new method for calculating the transient motions of dynamic instability.

In addition, we studied the transient motion of waves and pulses through air, and other gases, and through solid structures. These motions can be caused by phenomena such as explosions, the passage of aircraft or missiles through sonic speed, maneuvers and other motions of aircraft. Appropriate

asymptotic and perturbation methods were developed or applied to specific problems. This led to reports AFH 3, 9, 10, 11, 14, 20, 27, and 35. The development of new mathematical techniques for analyzing wave propagation in a variety of random media are considered in AFH 1, 2, 6, 7, and 8.

Other investigations were concerned with vortex motion of fluids, AFH 19 and 28. Other problems in fluid dynamics are treated in AFH 29, 31, and 32. The elasticity of composite media was studied in AFH-13, while AFH-12 contains a new method for analyzing contact problems in elasticity.

Finally, new asymptotic methods were developed and applied in AFH 15, 16, 18, 21, and 22 for treating neutron transport and diffusion problems.

The common feature of most of this work is asymptotic and perturbation analysis. The techniques which have been useful in solving the particular problems of this project are of interest, and applicable to many other problems.

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AFH Reports and Publications

- AFH-1 I. Besieris Reciprocity Relations for Uniformly Moving
Magnetoelectric Media
Pub: Proceedings of the IEEE, 60, 2, (1972)
pp. 229-230.
- AFH-2 I. Besieris Stochastic Master Equations: A Perturbative
Approach
Pub: J. Math. Phys., 13, 3, (1972), pp. 358-360.
- AFH-3 B. Seymour Resonant Acoustic Oscillations with Damping;
M. Mortell Small Rate Theory
Pub: J. Fluid Mech., 58, Part 2 (1973)
pp. 353-373.
- AFH-4 B. Nicolaenko The Spectral Theory of Linearized Special
J. K. Thurber Relativistic Model Boltzmann Equations
Acc: Proceedings of the Rarefied Gas Symposium
- AFH-5 A. Callegari Nonlinear Stability Problems for the Sine-Gordon
E. Reiss Equation
Pub: J. Math. Physics, 14, -2, (1973) pp. 267-276.
- AFH-6 I. Besieris Kinetic Equations for the Quantized Motion of a
F. D. Tappert Particle in a Randomly Perturbed Potential Field
Pub: J. Math. Physics, 14, 12, (1973) pp. 1829-1836.
- AFH-7 I. Besieris Wave Packet Spreading on a Random Transmission
F. D. Tappert Line
Pub: J. Applied Physics, 44, 5, (1973) pp. 2119-2121.
- AFH-8 I. Besieris Propagation of Frequency Modulated Pulses in a
F. D. Tappert Randomly Stratified Plasma
Pub: J. Math. Physics, 14, 6, (1973) pp. 704-707.
- AFH-9 D. S. Ahluwalia Elastic Waves Produced by Surface Displacements
J. B. Keller
R. Jarvis Pub: SIAM J. Appl. Math., 26, 1, (1974) pp. 108-119.
- AFH-10 D. S. Ahluwalia Uniform Asymptotic Solution of Eigenvalue Problems
J. B. Keller for Convex Plane Domains
Pub: SIAM J. Appl. Math., 25, 4 (1973) pp. 583-591.

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|--------|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| AFH-11 | D. S. Ahluwalia
J. B. Keller
B. Matkowsky | Asymptotic Theory of Propagation
in Curved and Nonuniform Waveguides
<u>Pub:</u> J. Acoustical Soc. Amer., <u>55</u>
(1974), pp. 7-12. |
| AFH-12 | A. J. Callegari
J. B. Keller | Contact of Inflated Membranes with
Rigid Surfaces
<u>Pub:</u> J. Appl. Mech., <u>41</u> , 1, (1974),
pp. 189-191. |
| AFH-13 | J. B. Keller
J. Flaherty | Elastic Behavior of Composite Media
<u>Pub:</u> CPAM, XXVI (1973) pp. 565-580. |
| AFH-14 | J. B. Keller
J. Rosenfeld | Wave Propagation in Elastic Rods
of Arbitrary Cross Section
<u>Pub:</u> J. Acoustical Soc. Amer., <u>55</u> , 3,
(1974), pp. 555-561. |
| AFH-15 | J. B. Keller
E. Larsen | Asymptotic Solution of Neutron Transport
Problems for Small Mean Free Paths
<u>Pub:</u> J. Math. Phys., <u>15</u> , 1 (1974)
pp. 75-81. |
| AFH-16 | E. Larsen
P.F. Zweifel | On the Spectrum of the Linear Transport
Operator
<u>Pub:</u> J. Math. Phys., <u>15</u> , 11 (1974) pp. 1987-
1997 |
| AFH-17 | A. J. Callegari
E. L. Reiss
L. Bauer | On the Collapse of Shallow Membranes
<u>Pub:</u> <u>Nonlinear Elasticity</u> , Academic
Press, 1973, pp. 1-30. |
| AFH-18 | E. Larsen | Solution of Neutron Transport Problems
in L_1
<u>Pub:</u> J. Math. Anal. & Applics., <u>28</u>
(1975) pp. 729-746. |
| AFH-19 | J. Norbury | Steady Vortex Pairs in an Ideal Fluid
<u>Pub:</u> CPAM, <u>28</u> , 6, (1975) pp. 679-700. |
| AFH-20 | G. Rosenfeld
J. B. Keller | Wave Propagation in Non-Uniform
Elastic Rods
<u>Pub:</u> J. Acoustical Soc. Amer., <u>57</u> , 5,
(1975) pp. 1094-1096. |
| AFH-21 | E. Larsen | Neutron Transport and Diffusion in
Inhomogeneous Media I
<u>Pub:</u> J. Math. Phys., <u>16</u> , 7, (1975)
pp. 1421-1427. |

- AFH-22 E. W. Larsen Neutron Transport and Diffusion
in Inhomogeneous Media II
Pub: Nuclear Sci. and Engg.,
60 (1976), pp. 357-368.
- AFH-23 F. C. Hoppensteadt Slowly Modulated Oscillations in
D. S. Cohen Nonlinear Diffusion Processes
R. M. Miura Acc: SIAM J. Appl. Math.
- AFH-24 B. J. Matkowsky Singular Perturbations of
E. L. Reiss Bifurcations
Acc: SIAM J. Appl. Math.
- AFH-25 E. L. Reiss Imperfect Bifurcation
Acc: Adv. Seminar on Bifurca-
tion Theory, Univ. of
Wisconsin.
- AFH-26 F. C. Hoppensteadt The Transient States in the Onset
of Convection in the Benard
Problem
Acc: Proc., Journees Math. sur
les Perturbation Singulieres,
Springer-Verlag.
- AFH-27 A. J. Callegari On the Singular Behavior of Linear
M. K. Myers Acoustic Theory in Near-Sonic Duct
Flows
Acc: J. of Sound and Vibrations.
- AFH-28 A. J. Callegari Analysis of the Motion and Decay
L. Ting of a Curved Vortex Filament
Acc: SIAM J. Appl. Math.
- AFH-29 A. J. Callegari A Nonlinear Singular Boundary
A. Nachman Value Problem in the Theory of
Power Law Fluids
Acc: SIAM J. Appl. Math.

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AFH-30	F. C. Hoppensteadt W. L. Miranker	Multi-Time Solution Methods for Systems of Difference Equations <u>Acc:</u> Stud. in Appl. Math.
AFH-31	A. J. Callegari A. Nachman	A Nonlinear Boundary Value Problem in Shock Wave Boundary Layer Interaction <u>Sub:</u> J. Math. Analysis and Applications.
AFH-32	A. J. Callegari M. B. Friedman	The Blow Off Problem—An Analytical Study <u>Sub:</u> SIAM J. Appl. Math.
AFH-33	F. C. Hoppensteadt S. Persek	Nonlinear Stability Analysis of Highly Oscillatory Systems with Applications to Benard Convection in a Rotating Frame In preparation.
AFH-34	E. L. Reiss B. J. Matkowsky L. Putnick	Buckling of Imperfect, Rectangular Plates In preparation.
AFH-35	E. L. Reiss	On the Derivation of Linear Beam Theory In preparation.
AFH-36	E. L. Reiss B. J. Matkowsky L. Putnick	Secondary States of Rectangular Plates In preparation.
AFH-37	E. L. Reiss L. Putnick B. J. Matkowsky	Nonlinear Periodic Oscillations of Rectangular Plates In preparation.